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Modern Concepts of Cardiovascular Disease

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SURGICAL CLOSURE OF THE PATENT DUCTUS ARTERIOSUS

Many individuals with a persisting ductus arteriosus will live through a normal span of years, but others are cut short by complications arising from this form of arterial shunt. The most common hazards associated with the patent ductus arteriosus are: 1. retarded physical growth (because of diminished peripheral blood flow); 2. cardiac failure (because of increased burden imposed by the fistula); 3. subacute bacterial endocarditis (or endarteritis of the pulmonary artery). If the ductus is large, the individual has a considerable chance of encountering one or both of the first two complications. If the ductus is small, there is a less severe strain on the cardiovascular system, but the patient is still vulnerable to a streptococcus viridans infection which when once established usually terminates fatally. Cardiologists have not yet amassed sufficient data to present accurate statistics on the frequency of complications arising from the patent ductus arteriosus but it is evident that the dangers are high enough to warrant surgical attack on the lesion provided the mortality from this procedure can be reduced to a reasonable figure. Experience to date indicates that a competent operator is able to keep the mortality rate well below 10 per cent; additional familiarity with the technique in the future will probably diminish this risk to a lower level.

Symptoms and Signs of Patent Ductus Arteriosus

The manifestations of this congenital abnormality may be entirely lacking in infancy, are apt to be confusing during the first few years of life, but are almost always typical after the fourth or fifth year. When there are no other associated cardiac defects, the findings are such that a correct diagnosis can be made with a high degree of accuracy. There may be no history of physical incapacitation or cardiac embarrassment; conversely, there may be a mild dyspnoea, tachycardia, or a pounding cardiac impulse. Orthopnoea, peripheral edema, or other evidence of frank cardiac failure is observed in only a small percentage of cases. In rare instances death has appeared suddenly and without satisfactory explanation. Since the vascular shunt is from the aorta to the pulmonary artery, these individuals never exhibit cyanosis except when there is impending death and the arterial pressure terminally falls so low that the direction of blood-flow through the ductus is reversed.

A precordial thrill may not be found, but if the ductal shunt is large there is a thrill which is either systolic in time or is continuous with systolic accentuation. The thrill is maximal over the second or third interspace to the left of the sternum. The murmur is almost always a continuous one. It is greatly accentuated during systole and reaches a maximum intensity during the end of systole and in the first part of diastole. Usually it has a characteristic rumbling or "machinery" quality, but if the ductus is small this is less evident. The murmur is loudest in the second or third interspace to the left of the sternum but the systolic portion of it may be heard over the apex, in the axillae, and over the back to the left of the spine. The pulmonary second sound may be greatly accentuated in intensity or it may be completely overshadowed by the loud murmur. The transverse diameter of the heart may be slightly increased, but marked cardiac hypertrophy is rare. The systolic blood pressure is seldom abnormal. If the ductus is small, the diastolic figure is likewise normal; but if the ductus is large, the diastolic pressure is greatly diminished. When the pulse pressure is high, a capillary pulsation is visible in the peripheral-vascular bed and a water-hammer or collapsing type of pulse is observed over the large arteries. There is no clubbing of the nails. Physical growth may be retarded and may be below the expected normal for the age and sex of the individual, but in general this is only true if the other physical findings indicate that the ductus arteriosus is of large calibre. There is no polycythemia.

Electrocardiographic Findings

The vast majority of electrocardiagraph tracings show no important variation from the normal; in some instances these may be minor changes indicating myocardial damage. It is rare to have any evidence of axis deviation; certainly a right axis deviation should at once arouse suspicions of some other abnormality. Slight left axis deviation may be occasionally found in a patient who has a large ductus and who is beginning to evince left-sided cardiac failure.

Roentgenographic Findings

The transverse measurement of the heart may be normal or it may be increased to slightly more than half of the internal diameter of the chest. Marked enlargement is rare. The pulmonary artery usually protrudes somewhat toward the left, but this is not a universal finding. Mild to moderate congestion in the pulmonary fields is common, and is apt to be more marked in the right lower lobe than in other parts of the lungs.

Fluoroscopic examination (or kymographic study) shows the heart to be beating with an increased vigor and with an increased amplitude of contraction — particularly if the ductal leak is large. There is an increased pulsation of the aortic arch and the pulmonary artery, the amplitude of distention and collapse being directly related to the size of the ductal lumen. The right anterior oblique view indicates some posterior enlargement of the left auricle in most instances. When the ductus is very large there is a visible pulsation of arteries within the lung substance — a so-called "hilar dance."

Visualization of the chambers of the heart by intravenous injection of the 70 per cent Diodrast is rarely necessary to establish the diagnosis but it

FEB 11

may have some value in ruling out other associated lesions. The ductus itself cannot be visualized by this means but some evidence of its presence is suggested by an enlarged left auricle, an enlarged left ventricle, and a prolonged circulation of blood through the pulmonary-vascular beds (in the absence of other left-right cardiac shunts).

Indications for Operation

In each patient the dangers of the untreated abnormality should be weighed against those of operative intervention. The former hazards are usually remote ones, while the latter ones are necessarily more imminent and closely follow the surgical procedure. Nevertheless, that course should be chosen which provides the best chance for prolonged and satisfactory life. If there has been stunting of physical growth, cardiac embarrassment, voluntary limitation of physical activity, or evidence of a particularly large shunt, the risks of surgery are warranted and should be accepted.

If the ductus is small and does not give rise to any important symptoms, the indications for operation are much less clear. When first undertaking these operative procedures it was our opinion that a ductus should not be surgically closed merely in the hopes of preventing a possible bacterial endocarditis in the future. However, within the last two years it has become evident that the surgical mortality can be kept extremely low and that the indications for operation can be liberalized. While not intending to overemphasize the importance of superimposed streptococcus viridans infections, increasing experience is bringing to light a considerable number of individuals with this complication and it is our present feeling that the great majority of children and adolescent individuals with a patent ductus should be subjected to surgical ligation of the ductus in the effort to reduce the number of bacterial infections which might be encountered in later life.

In general, the operation should not be undertaken before the ages of four to six years because spontaneous closure or reduction in size of the ductus may occur up until this time. However, one child as young as twenty-two months of age has been successfully operated upon and complete obliteration of the vessel obtained. Broadly speaking, an individual who has reached the age of thirty to thirty-five without cardiac embarrassment and without subacute bacterial endocarditis has only a minimal chance of developing these complications in subsequent years. Therefore, the operation will have little or no use for patients beyond this age limit.

The size or age of the patient has little or no bearing on the degree of operative risk. However, the operative experience to date has shown that the softer, more pliable vessels of children can be more easily and effectively obliterated than can the more sclerotic and rigid ones of adult subjects. For this reason and also because of the desire to prevent atheromatous plaques in the pulmonary artery (from the swirling blood currents) which might become a site for bacterial growth, it is probably better to advise operation in childhood whenever possible rather than defer operation to the second or third decades of life.

Regarding advisability of operation for individuals who already have a proved bacterial endocarditis (or pulmonary endarteritis) there is still considerable variance of opinion. Certainly operation is not universally desirable as some authors have intimated, because the extreme friability of the ductus under these conditions may lead to fatal rupture if it is handled at operation, whereas the individual may have lived for many months if left untreated or if carried along solely on chemotherapy. In spite of the great risk, it is now apparent that patients with superimposed bacterial infections have been successfully treated by surgery (with and without chemotherapy). If the infection has been of long-standing surgery probably has little or nothing to offer, but in the first few months of the disease closure of the ductus appears to be of definite value.

Operative Procedure

The ductus arteriosus can be adequately and safely brought into view by a left, transpleural approach which temporarily collapses the left lung during the operation. After the mediastinum is opened, the ductus must be freed with great care and the operator must have exact knowledge of the reginal anatomy. In most instances the ductus is too short to permit division and hence must be ligated with suitable material. The left lung is immediately re-expanded and the chest is tightly closed without drainage. In two recent cases complete division of the ductus has been successfully performed. These operations, while long and tedious, are well tolerated; hospitalization averages ten to fourteen days.

Results of Surgical Closure of the Ductus Arteriosus

To date, thirty individuals, varying in age from twenty-two months to thirty years have been operated upon by the author. There have been two deaths. One resulted from a staphylococcus aureus infection, presumably originating from faulty skin preparation. The other occurred during the third postoperative week from erosion of the ductus by the ligatures.

Those individuals with stunted physical growth have shown considerable augmentation in weight following the operation, this change being presumably due to increased peripheral flow of blood. Those individuals with evidence of cardiac embarrassment or even frank failure have been able to return to normal physical activity and have had an obvious increase in the amount of cardiac reserve. Some individuals have been operated upon with the idea of preventing future streptococcus viridans infection. None of these has developed this complication but the postoperative periods have been too short to make any final statement regarding what has been actually accomplished. However, it is reasonable to assume that closure of the ductus will diminish the formation of cholesterol plaques within the pulmonary artery, will prevent the entrance of oxygenated blood into the pulmonary artery, and will stop the swirling of blood within this vessel. All of these factors make less favorable conditions for growth of the streptococcus viridans and hence should diminish the incidence of future endocarditis or endarteritis.

Four adults have been operated upon in the presence of subacute bacterial endocarditis. In the first of these the infection was of long-standing (ten or eleven months) and operation has had no influence on the course of the disease. The other three had infections of shorter duration which had been brought under control by sulfonamide therapy. Two of these have survived operation for eight months and four months respectively and have had repeated negative blood cultures. The third has likewise had disappearance of all symptoms of infection, but the postoperatie course has been too short to indicate accurately what the ultimate result will be.

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